

B14

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
14 February 2002 (14.02.2002)

PCT

(10) International Publication Number  
WO 02/12797 A2

- (51) International Patent Classification<sup>7</sup>: F24F (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KI, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.
- (21) International Application Number: PCT/US01/24627
- (22) International Filing Date: 6 August 2001 (06.08.2001)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 09/635,374 9 August 2000 (09.08.2000) US (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- (71) Applicant: EMERSON ELECTRIC CO. [US/US]; 8000 W. Florissant, St. Louis, MO 63136 (US).
- (72) Inventors: LENNART, Stahl; 1717 Poinciana Lane, Plano, TX 75075 (US). BELADY, Christian; 2202 Amherst Circle, McKinney, TX 75070 (US). Published: — without international search report and to be republished upon receipt of that report
- (74) Agent: ALLEN, Billy, C., III; Howrey Simon Arnold & White, LLP, 750 Bering Drive, Houston, TX 77057-2198 (US). For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 02/12797 A2

(54) Title: CONFIGURABLE SYSTEM AND METHOD FOR COOLING A ROOM

(57) Abstract: A method and system are disclosed for cooling a room having one or more heat generating objects. A number of heat exchangers are disposed adjacent a floor or ceiling and extends substantially entirely or partially between the walls of the room. A fan unit is disposed adjacent the heat exchanger and draws or blows cooled air from the heat exchanger and directs the drawn air into the room. The fan unit is capable of being repositioned along a different portion of the heat exchanger so as to redefine the flow of cooled air into the room. The cooling system components are modularized enabling configuration of a number of components to cool a room.

-1-

**CONFIGURABLE SYSTEM AND METHOD FOR COOLING A ROOM****CROSS REFERENCE TO RELATED APPLICATIONS**

This application is related to U.S. Applications for Patent, Serial No. 09/617,213, filed July 17, 2000, entitled "Overhead Cooling System With Selectively Positioned Paths of Airflow",  
5 and Serial No. 09/617,391, filed July 17, 2000, entitled "Reconfigurable System and Method for Cooling Heat Generating Objects", both of which are incorporated herein by reference.

**BACKGROUND OF THE INVENTION****10      Technical Field of the Invention**

The present invention relates to cooling systems for cooling a room having electronic equipment therein, and particularly to cooling systems for a computer room that are configurable to allow customized air flow in proximity to the location of computer equipment in the computer room.

**15      Background and Objects of the Invention**

The growth of the computer industry and telephony over the past few decades has been phenomenal. The integration of these technologies, for example, in telecommunications switching systems, has lead to greater and greater efficiencies as larger numbers of communications are  
20 handled by fewer components, which are typically housed in a central control room.

One problem inherent with many existing cooling systems for electronic equipment is rigidity. Many existing cooling systems are built into and/or under the flooring of a temperature-controlled room having equipment needing to be cooled. Such cooling systems employ fixed  
25 conduits or other piping for directing cooled air along a subsurface of the flooring and upwardly through the floor and towards the equipment to be cooled. The upwardly directed cooled air is in proximity to the equipment. In the event the temperature characteristics within the temperature-cooled room changes, such as by the equipment being moved within the room or by additional equipment being added therein, it is very difficult to modify the cooling system accordingly. For  
30 instance, the conduits have to be detached from their fixed positions and repositioned, or replaced

-2-

in favor of differently sized conduits. Consequently, altering the cooling characteristics of existing cooling systems frequently proves a costly adventure.

5 Floor-based cooling systems present additional difficulties other than structural rigidity. For instance, floor-based cooling systems that do not utilize conduits for passing cooled air occupy more area so that equipment cabling and other obstructions do not cause uneven air distribution or a reduction in air pressure. Such systems require the equipment cabling to be plenum rated, thereby increasing system cost. Floor-based cooling systems also possess the tendency to distribute noise and vibrations, which may effect the operation of the equipment to be cooled.

10

In addition, floor-based and other existing cooling systems have a rather limited cooling capability. For instance, existing cooling systems have heat densities of approximately 80 watts per square foot ( $\text{W}/\text{ft}^2$ ) with planned cooling systems being claimed to possess heat densities of up to 150  $\text{W}/\text{ft}^2$ . Although perhaps adequate for some current systems, cooling systems having such heat densities may not effectively cool many of today's equipment, such as state-of-the-art computational equipment.

15

As is readily apparent, if equipment is not effectively cooled, the internal temperature of the electronic components in the equipment substantially increases, thereby leading to significantly reduced system performance and, in some cases, total system failure. If a cooling system inefficiently cools the equipment, either the equipment may fail due to increased operating temperature or the costs for cooling the equipment may be unnecessarily high. What is needed, then, is a cooling system having its cooling characteristics closely tailored to the heating characteristics of the equipment to be cooled.

20

25

## SUMMARY OF THE INVENTION

The present invention overcomes the above-discussed shortcomings and satisfies a significant need for a cooling system for cooling a room having one or more heat generating objects.

30 The cooling system includes at least one heat exchanger disposed beneath the floor and extending

-3-

substantially entirely between the walls of the room, and a fan unit disposed between the at least one heat exchanger and the floor and being selectively positioned along the at least one heat exchanger so as to draw air therefrom and blow the drawn air into the room, e.g., to a room portion having heat dissipation problems. By positioning the fan unit along the heat exchanger to adjustably provide a cooled airflow proximally to heat generating objects in the room, the present invention provides a reconfigurable cooling system that is selectively customized to particular room cooling requirements. The above reconfigurable system is also applicable to a heat exchanger installed in the ceiling above the various heat generating objects, enabling dual heat exchanging in order to further improve thermal efficiency.

10

The operation of the embodiment of the present invention includes initially positioning the fan unit in relatively close proximity to one or more heat generating objects in the room. Next, the fan unit draws cooled air through the heat exchanger and blows the drawn air through a first portion of the floor or ceiling into the room near the heat generating objects. In the event thermal characteristics of the room change, the fan unit may be moved along the heat exchanger so that cooled air drawn from the heat exchanger is blown through a second portion of the floor as desired, thereby adjustably configuring the air flow to effectuate cooling.

15

The present invention is also directed to a system better exploiting the reconfigurability aspects of the above embodiments. In particular, through modularization of the fan units and heat exchangers, cooling difficulties in large rooms may be addressed in an economic manner. The interchangeability and interlinkage of the components would also permit easier repair and less downtime.

20

25

## BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the system and method of the present invention may be obtained by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

-4-

FIGURE 1 is a side elevational view of a cooling system in association with a room having heat generating equipment therein in accordance with an embodiment of the present invention having a heat exchanger installed in a subfloor portion of a room;

5        FIGURE 2 is a plan view of the cooling system of FIGURE 1 taken along the A-A line of FIGURE 1;

FIGURE 3 is a side elevational view of a cooling system in association with a room having heat generating equipment therein in accordance with another embodiment of the present invention  
10    having a heat exchanger installed in a ceiling portion of a room;

FIGURE 4 is a plan view of the cooling system of FIGURE 3 taken along the B-B line of FIGURE 3;

15        Figures 5 and 6 are side elevational views illustrating an operation of the cooling system of FIGURES 1-4; and

FIGURE 7 is a side elevational view of a cooling system in association with a room having heat generating equipment in accordance with a further embodiment of the present invention, having  
20    heat exchangers installed in both the subfloor and ceiling portions of the room; and

FIGURE 8 is a plan view of a modular configuration of numerous cooling system components, as described in connection with FIGURES 1-7, arranged to cool a room.

## 25    **DETAILED DESCRIPTION OF THE PREFERRED EXEMPLARY EMBODIMENTS**

The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which a preferred embodiment of the invention is shown. This invention may, however, be embodied in many different forms and should not be construed as being limited  
30    to the embodiment set forth herein. Rather, the embodiment is provided so that this disclosure will

-5-

be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

Referring to Figures 1-3, there is shown a cooling system, generally designated by the reference numeral 100, according to an embodiment of the present invention. Cooling system 100 is adapted to provide cooled air to a room, generally designated by the reference symbol R, such as a room having electronic equipment or other heat generating objects H therein. Room R has a raised floor F that allows air to pass therethrough, such as a floor F having a grid-like pattern, permitting air to permeate therethrough.

Cooling system 100 includes at least one heat exchanger 110 through which a coolant fluid is passed. Heat exchanger 110 may be a cooling coil or other comparable device, as is understood in the art, and is preferably disposed substantially horizontal with respect to the floor F. Air is cooled by being directed through or in proximity to the heat exchanger 110. According to the embodiment of the present invention shown in FIGURE 1, and shown in FIGURE 2 in a sectional plan view along the A-A line, heat exchanger 110 is sized so as to extend along floor F substantially entirely between the walls W of room R, individually designated for convenience in FIGURE 2 as W1, W2, W3 and W4. In this way, air is capable of passing in a transverse (vertical) direction through or in proximity to the heat exchanger 110 entirely along floor F and cooled thereby. Coolant temperature and flow rate within the heat exchanger 110 may be controlled manually or automatically, as is understood in the art.

In order to focus a flow of cooled air from heat exchanger 110 towards heat generating objects H in room R, cooling system 100 preferably includes one or more fan units 120. Fan units 120 are preferably disposed between the heat exchanger 110 and the floor F. Fan units 120 are adjacent only a portion of the surface of the heat exchanger 110, as shown by the plan view of cooling system 100 in FIGURE 2. In this embodiment, each fan unit 120 is operated to draw cooled air from the heat exchanger 110 and blow the drawn air upwards into room R, thereby cooling the heat generating objects H disposed therein.

-6-

Each fan unit 120 preferably includes one or more individual fans 130. The operating speed of the fans 130 may be fixed, manually varied or automatically varied to provide the desired cooling capacity. Although each fan unit 120 is shown as including four discrete fans 130 (FIGURE 2), it is understood that the number of fans 130 in each fan unit 120 may vary depending upon the operating requirements of cooling system 100. It should also be understood that the individual fans 130 may be vertically aligned to direct the air upwards or may be individually adjustable to more directly fine-tune the cooling, e.g., the fans 130 pivot about one or more axes to permit more angular air flows, if desirable.

10 Cooling system 100 may include a tray or frame assembly 140 disposed between the heat exchanger 110 and the floor F, by which the fan units 120 (and fans 130) are supported. Tray assembly 140 may be attached to the heat exchanger 110. Alternatively, tray assembly 140 may be unattached to the heat exchanger 110. Tray assembly 140 may include a pair of ledges 140A, which are in substantially parallel relation to each other. Referring to the embodiment shown in FIGURE 15 2, each ledge 140A extends from one wall W1 to another wall W2 opposite thereto. End portions of the fan units 120 rest on the ledges 140A of the tray assembly 140. It is understood, however, that the fan units 120 may be attached to the tray assembly 140 using other mechanisms, such as screws, nuts and bolts, clamp mechanisms or the like. Although FIGURE 2 shows the ledges 140A disposed parallel to walls W3 and W4, it is understood that the ledges 140A may be instead (or additionally) 20 disposed in a spaced relation from parallel walls W3 and W4.

Fan units 120 may be positioned along the heat exchanger 110 and/or tray assembly 140 so as to blow cooled air in proximity to heat generating objects H in room R. As is understood in the art, with the fan units 140 being supported by ledges 140A, the fan units 140 may be selectively 25 repositioned or slidably disposed along the tray assembly 140 and the heat exchanger 110. In this way, cooling system 100 is reconfigurable to account for changes in the temperature characteristics of room R, such as changes due to new heat generating objects H being placed in room R or existing heat generating objects H being moved therein, deleteriously or suboptimally altering the air flow.

-7-

Representative air flows within room R are designated by the reference numeral 150A, both rising and falling, which upon passing through the permeable floor F, designated by the reference numeral 150B, and through the heat exchanger 110, are cooled thereby. The cooled air, designated by the reference numeral 150C is then blown upward into room R, as illustrated.

5        With reference now to FIGURE 3, the cooling system, generally designated therein by the reference numeral 300, in this embodiment has a heat exchanger 310, also shown in FIGURE 4 in a sectional plan view along the B-B line, and fan units 320 disposed in a ceiling C, overhanging the various heat generating objects H within the room R. In particular, the fan units 320 are also selectively positioned or slidably disposed, and repositioned along ceiling C so as to blow air  
10    downwardly into room R through ceiling C, which also has a grid-like pattern allowing passage of air therethrough. As with the orientation to the floor F embodiment of FIGURES 1 and 2, the heat exchanger 310 and fan units 320 parallel and adjacent thereto are substantially horizontal with respect to the ceiling C. Cooling system 300 includes a tray or frame assembly 340 disposed adjacent ceiling C and extending from one end of room R to an opposite end thereof, e.g., from W1  
15    to W2 as illustrated in FIGURE 4. Tray assembly 340 includes a pair of ledges 340A that are in substantially parallel relation to each other. Referring to the embodiment shown in FIGURE 4, each ledge 340A extends from one wall W1 to another wall W2 opposite thereto. End portions of the fan units 320 rest along the ledges 340A of tray assembly. It is understood, however, that the fan units 320 may be attached to the tray assembly 340 using other mechanisms, such as screws, nuts and  
20    bolts, clamp mechanisms or the like. Although FIGURE 4 shows ledges 340A disposed along parallel walls W3 and W4, it is understood that the ledges 340A may be instead disposed in spaced relation from parallel walls W3 and W4.

Representative air flows, designated by the reference numeral 350A, in this embodiment rise  
25    from the heat generating devices H through the permeable ceiling C and overhead heat exchanger 310 to enter the fan unit 320, the inflow designated by the reference numeral 350B. The air flow 350B is then blown through the fan unit 320 either through the heat exchanger 310 for a second cooling, designated by the reference numeral 350C, or not, designated by the reference numeral 350D, which bypasses the heat exchanger 310. The floor F in this embodiment may or may not be



-8-

permeable. If permeable, however, as shown for convenience in FIGURE 3, then the air flows pass therethrough back into room R, as designated by the reference numeral 350E.

It should be understood from the embodiments shown in FIGURES 1-4 that the fan units  
5 120/320 may be positioned to either draw air through the heat exchanger, such as the embodiment shown in FIGURES 1 and 2, or push air through the heat exchanger, such as the embodiment shown in FIGURES 3 and 4. Accordingly, the fan units may be positioned either way in the respective embodiments to better effectuate the cooling needs and space requirements of the particular room R in question.

10

With reference to Figures 5 and 6, the operation of a combined cooling system, generally designated by the reference numeral 500, will now be described. As shown in FIGURE 5, upper fan unit 520A and lower fan units 520B are initially positioned along respective tray assemblies 540A and 540B so as to be in first positions relative to rows of heat generating objects H disposed  
15 therebetween. Fan unit 520A is shown in FIGURE 5 positioned along ceiling C in a first position relative to the heat generating objects H disposed below. Next, coolant is forced through a heat exchanger 510A so as to effectively cool air in proximity thereto. The coolant is maintained at the desired temperature and flow rate, under manual or automatic control, as described. The fan unit 520A is then activated to force air through the heat exchanger 510A, as generally illustrated by the  
20 reference numeral 550A. The downward air flows then pass the heat generating devices H and through the floor F, as designated by the reference numeral 550B.

Fan units 520B are, in turn, positioned along the floor F in a first position relative to the heat generating objects H disposed above. Coolant is then forced through a heat exchanger 510B, cooling  
25 the air in proximity thereto, and fan units 520B draw the cooled air from the heat exchanger 510B, designated by the reference numeral 550C, and blow the cooled air upwards through the floor F along airflow paths, as generally illustrated by the reference numeral 550D. The rising air flows, designated by the reference numeral 550E, pass through the ceiling C and through the heat exchanger 510A for passage to the fan unit 520A to close the cycle.

-9-

Fan units 520A and 520B are activated to run at a desired speed, under manual or automatic control, as described. Alternatively, the speed of the fan units 520A and 520B are individually set. Heat exchangers 510A and 510B, which may be interconnected, and fan units 520A and 520B maintain room R at the desired temperature with the desired temperature gradient.

5

In the event the thermal characteristics within room R change, however, such as due to heat generating objects H being moved or additional heat generating objects H being placed in room R, the fan units 520A and 520B may be repositioned along a different portion of the respective heat exchangers 510A and 510B and/or tray assemblies 540A and 540B accordingly, as illustrated in  
10 FIGURE 6. Similarly, fan units 520A and 520B may be repositioned along a different portion of ceiling C and floor F, respectively. Once fan units 520A and 520B are repositioned and activated, cooled air from the respective heat exchangers 540A and 540B is blown into room R in proximity to heat generating objects H along other airflow paths, generally designated therein by the reference numerals 560A and 560E, respectively, which should address the heating problems of the new  
15 configuration.

One advantage provided by the cooling systems according to the present invention concerns heat density. Cooling systems in accordance with the present invention are capable of handling heat densities of approximately 200 W/ft<sup>2</sup> or more, e.g., up to approximately 500 W/ft<sup>2</sup>. Relative to  
20 existing conventional cooling systems, the cooling systems of the present invention are more capable of meeting the cooling demands of tomorrow's heat generating equipment.

It is understood that heat exchangers 110/310/510 and tray assemblies 140/340/540 may be located in different locations relative to room R. For instance, according to another embodiment of  
25 the present invention, a cooling system, generally designated in FIGURE 7 by the reference numeral 700, may include a heat exchanger 710 disposed adjacent ceiling C. As shown in FIGURE 7, fan units 720A are disposed between the heat exchanger 710 and the ceiling C. When activated, the fan units 720A draw cooled air from the heat exchanger 710 and direct the cooled air downwardly into room R through the gridwork of the ceiling C. A tray and/or frame assembly 740A is disposed  
30 between the heat exchanger 710 and the ceiling C to support the respective fan units 720A over

-10-

ceiling C. The fan units 720A are selectively positioned or slidably arranged along portions of the heat exchanger 710 and/or the tray assembly 740A based in part upon the thermal characteristics of room R. A fan unit 720B is disposed beneath floor F along a tray assembly 740B. When activated, the fan unit 720B blows ambient air upwardly into room R without the benefit of further cooling  
5 through a heat exchanger. Representative air flows through cooling system 700 are illustrated by the reference numerals 750A-750E, also illustrating a double cooling aspect of the present invention.

It should, of course, be understood that the heat exchanger in FIGURE 7 could alternatively be located below the floor F with the fan unit 720B blowing cooled air upward while the fan units  
10 720A above blow ambient air downwardly, as illustrated. As discussed hereinabove in connection with FIGURES 5 and 6, having heat exchangers and fan units both above and below the heat generating devices H provides better coverage for cooling the devices H from a variety of angles and, by virtue of the increased cooling capacity, provides greater cooling coverage.

15 It should also be understood that although the embodiments shown cover a room R and via slidable fan units offer coverage of the entire room R, the principles of the present invention may be readily adopted to provide coverage to a portion of a room whether from below, above or both. This "local" solution may be employed to address cooling problems in a portion of a room, e.g., a corner, without subjecting the entire room to the assemblage of heat exchangers, fan units and the  
20 like.

With reference now to FIGURE 8, there is illustrated the modularization of the components described hereinbefore to cover any size room or portion thereof. The transverse or perpendicular view illustrates a configuration either overhanging a room R having walls W, i.e., above the  
aforedescribed ceiling C, or underneath the floor F, as set forth in connection with the previous  
25 embodiments. Room R could be a large space for housing numerous heat generating devices H, e.g., a large number of servers or other computer equipment. An individual component of the configuration, generally designated by the reference numeral 800, is component 805, which is at the end of one row (of five) of five components, each connected to one another, e.g., structurally linked for stability and possible interconnectedness, e.g., the heat exchangers may have a single coolant

-11-

flow therethrough or otherwise subdivided to assure adequate cooling capacity throughout the configuration 800.

As shown in FIGURE 8, the positions of the individual fan units 820 in each component 805  
5 may vary to suit the needed cooling requirements in the room R. By individually orienting the  
respective fan units 820 (and the angle of air flow by orienting the respective fans therein), particular  
cooling requirements for the room R or portions thereof may be addressed easily by slidably  
arranging the fan units 820. It should be understood, of course, that although the modular  
arrangement shown in FIGURE 8 is square (5 x 5), any configuration is possible to meet the needs  
10 of the room R, e.g., 1 x 8, 2 x 4, 6 x 11, etc. As discussed, the modularity aspects of the present  
invention may be exploited either in overhead configurations, subfloor or combinations of each.

Additional Patent Applications of one of the inventors describe various features which may  
be implemented with the subject matter of the present invention, e.g., "System and Method for  
15 Separating Air Flows in a Cooling System", U.S. Serial No. 09/088,981, filed June 2, 1998, issued  
on March 7, 2000, as U.S. Patent No. 6,034,873; "System, Method and Apparatus for Purging  
Fluid", U.S. Serial No. 09/088,755, filed June 2, 1998, issued on November 2, 1999, as U.S. Patent  
No. 5,975,114; "Cooling System and Method for Distributing Cooled Air", U.S. Serial No.  
09/088,958, filed June 2, 1998; and "Spray Hood Protector in a Fluid-Based Cooling System", U.S.  
20 Serial No. 09/089,333, filed June 2, 1998, which are incorporated herein by reference.

The invention being thus described, it will be obvious that the same may be varied in many  
ways. Such variations are not to be regarded as a departure from the spirit and scope of the  
invention, and all such modifications as would be obvious to one skilled in the art are intended to  
25 be included within the scope of the following claims.

-12-

**Claims:**

1. A cooling system for cooling heat generating devices within a room having a floor, a plurality of walls and a ceiling, said system comprising:

5 at least one heat exchanger disposed substantially horizontal with respect to said floor and said ceiling; and

a first fan unit disposed substantially and horizontally parallel and adjacent said at least one heat exchanger, said first fan unit being selectively positioned along said at least one heat exchanger so as to direct air therefrom and blow said air into said room, thereby cooling said heat  
10 generating devices therein.

2. The cooling system according to claim 1, further comprising:

a second fan unit, said second fan unit being substantially parallel and adjacent said first fan unit, said first and second fan units being selectively and independently positioned along  
15 said at least one heat exchanger.

3. The cooling system according to claim 1, wherein said first fan unit comprises a plurality of fans.

20 4. The cooling system according the claim 3, wherein at least one of said fans is selectively and independently positioned within said first fan unit.

5. The cooling system according to claim 3, wherein the speed of at least one of said fans is variably controlled.

25

6. The cooling system according to claim 5, wherein the speed of at least one of said fans is automatically controlled.

7. The cooling system according to claim 5, wherein the speed of at least one of said  
30 fans is manually controlled.

-13-

8. The cooling system according to claim 1, further comprising:

a tray assembly disposed substantially and horizontally parallel to said at least one heat exchanger and said first fan unit, said first fan unit being positioned upon said tray assembly  
5 and selectively and independently positioned thereon.

9. The cooling system according to claim 8, wherein said first fan unit is slidably engaged along said tray assembly.

10 10. The cooling system according to claim 1, wherein said at least one heat exchanger and said first fan unit are disposed below said floor of said room, said first fan unit directing said air upwards into said room, said floor having a permeability to said air.

11. The cooling system according to claim 10, wherein said first fan unit is disposed  
15 below said at least one heat exchanger, said first fan unit blowing said air through said at least one heat exchanger into said room, whereby said air is cooled twice in a cycle through said room.

12. The cooling system according to claim 10, wherein said first fan unit is disposed above said at least one heat exchanger, said first fan unit drawing said air from said at least one heat  
20 exchanger and blowing said air into said room.

13. The cooling system according to claim 10, further comprising:

a second fan unit disposed above said ceiling of said room, said second fan unit directing air downwards into said room, said ceiling having a permeability to said air.

25

14. The cooling system according to claim 13, further comprising:

at least one additional heat exchanger disposed substantially and horizontally parallel and adjacent said second fan unit, said second fan unit directing air from said at least one additional heat exchanger into said room, whereby said air is cooled by said at least one heat exchanger and  
30 said at least additional heat exchanger when cycling through said room.

-14-

15. The cooling system according to claim 1, wherein said at least one heat exchanger and said first fan unit are disposed above said ceiling of room, said first fan unit directing said air downwards into said room.

5

16. The cooling system according to claim 15, wherein said first fan unit is disposed below said at least one heat exchanger, said first fan unit drawing said air through said at least one heat exchanger and blowing said air into said room.

10

17. The cooling system according to claim 15, wherein said first fan unit is disposed above said at least one heat exchanger, said first fan unit blowing said air through said at least one heat exchanger into said room.

18. The cooling system of claim 1, wherein a temperature of coolant passing through said at least one heat exchanger is variably controlled.

19. The cooling system according to claim 1, wherein said cooling system substantially covers an area of said room within said plurality of walls, said area having a position selected from the group consisting of: substantially along said floor and substantially along said ceiling.

20

20. The cooling system according to claim 19, wherein said area of said room covered by said cooling system is a portion of said room.

21. The cooling system according to claim 19, wherein said area of said room covered by said cooling system is substantially the area bounded by said plurality of walls.

22. A method for cooling heat generating devices within a room having a floor, a plurality of walls and a ceiling, said method comprising the steps of:

operating at least one heat exchanger to cool ambient air, said at least one heat exchanger being disposed substantially horizontally with respect to said floor and said ceiling; and

30

-15-

directing, by a fan unit disposed substantially and horizontally parallel and adjacent said at least one heat exchanger, said cooled ambient air from said at least one heat exchanger into said room, said fan unit being selectively positioned along said at least one heat exchanger, whereby said heat generating devices are cooled.

5

23. The method according to claim 22, further comprising the step of:  
redirecting said fan unit at a different position along said at least one heat exchanger.

24. The method according to claim 22, further comprising the step of:  
10 directing, by a second fan unit disposed substantially and horizontally parallel and adjacent said at least one heat exchanger, said cooled ambient air from said at least one heat exchanger into said room, said second fan unit being selectively and independently positioned along said at least one heat exchanger.

15 25. The method according to claim 22, wherein said at least one heat exchanger comprises a plurality of heat exchangers, respective fan units being associated therewith.

26. The method according to claim 25, wherein said plurality of exchangers are interconnected.

20

27. The method according to claim 25, wherein said respective fan units are slidably and independently positioned along respective heat exchangers.

28. The method according to claim 22, wherein said fan unit directs said cooled ambient  
25 air downwards from said ceiling into said room.

29. The method according to claim 22, wherein said fan unit directs said cooled ambient air upwards from said floor into said room.



-16-

30. A method for cooling heat generating devices within a room having a floor, a plurality of walls and a ceiling, said method comprising the steps of:

operating at least two heat exchangers to cool ambient air, a first of said heat exchangers being disposed substantially horizontally adjacent said floor, and a second of said heat exchangers being disposed substantially horizontally adjacent said ceiling; and

directing, by respective fan units disposed substantially and horizontally parallel and adjacent said first and second heat exchangers, said cooled ambient air from said first and second heat exchangers into said room, said fan units being selectively positioned along said first and second heat exchangers, whereby said air circulates through said first and second heat exchangers and said room to cool said heat generating devices disposed therein.

1/5

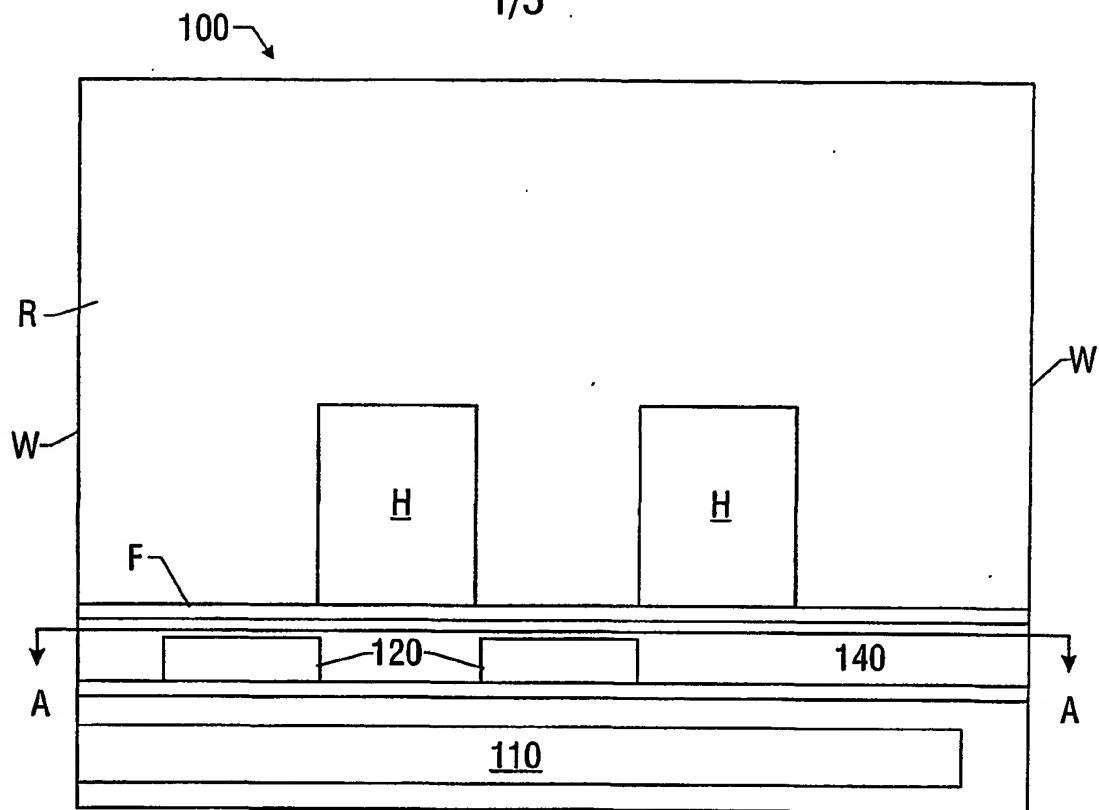


FIG. 1

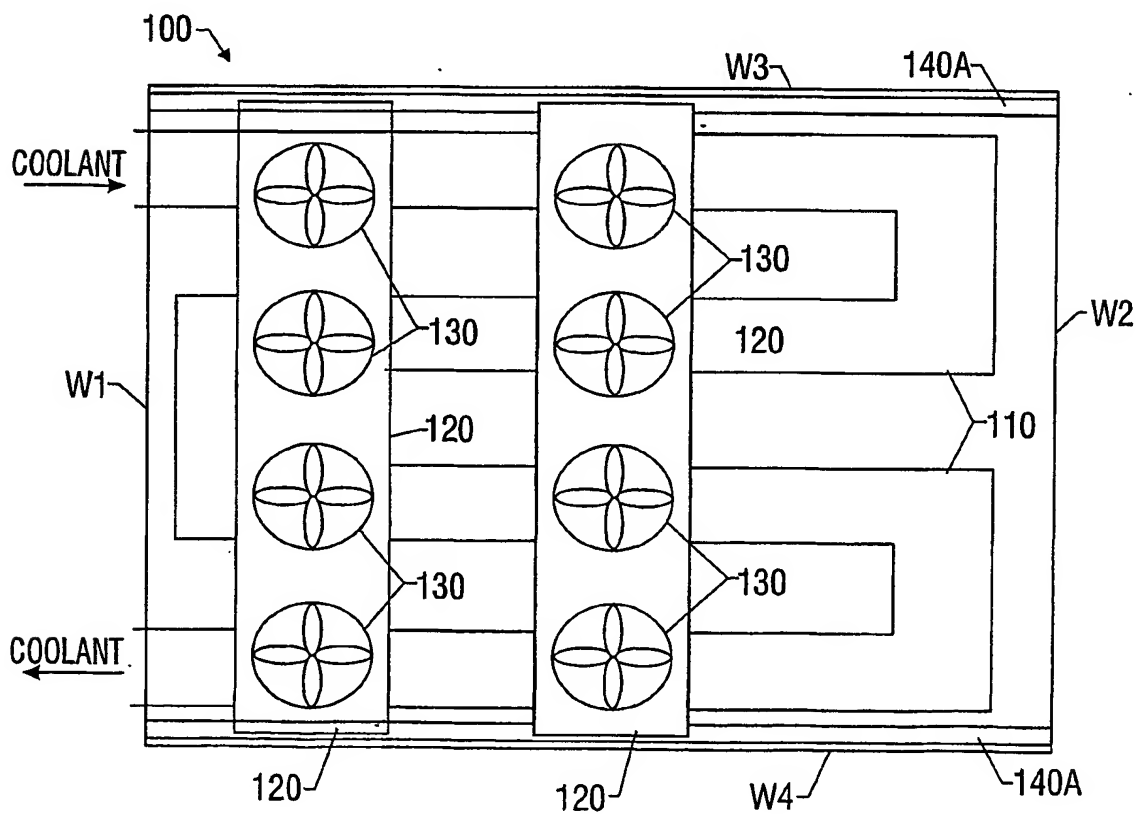


FIG. 2

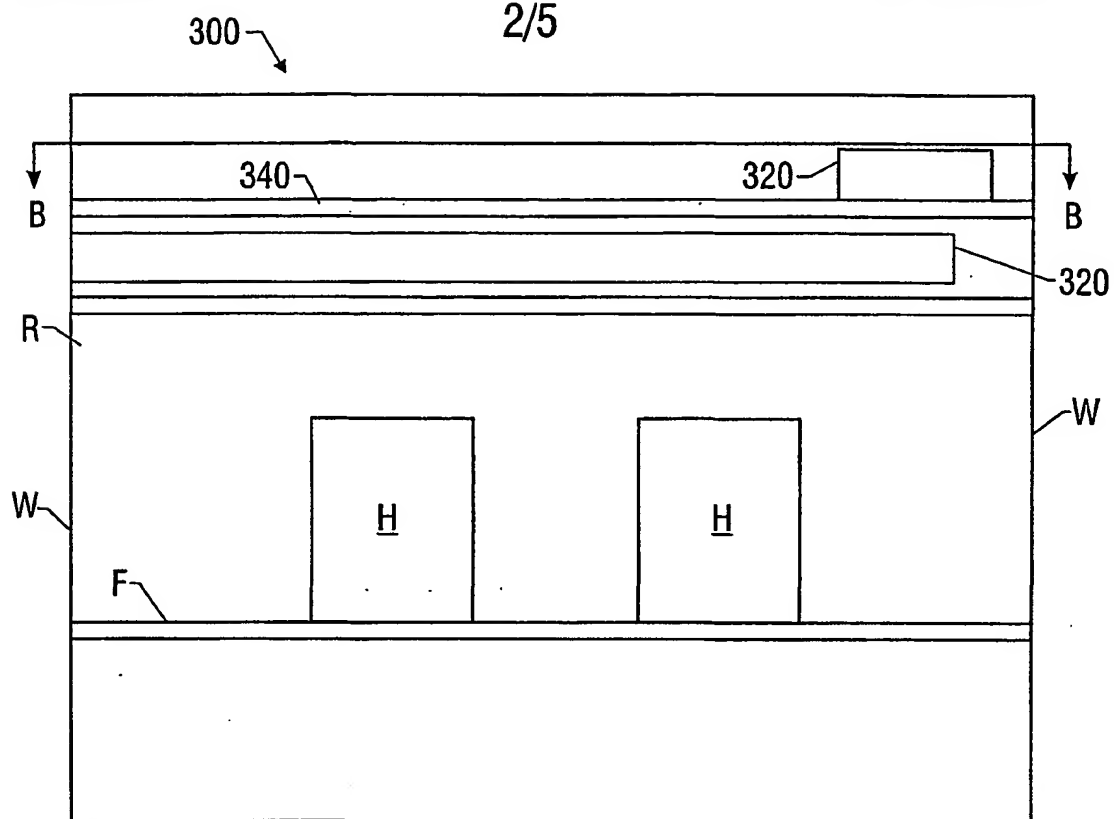


FIG. 3

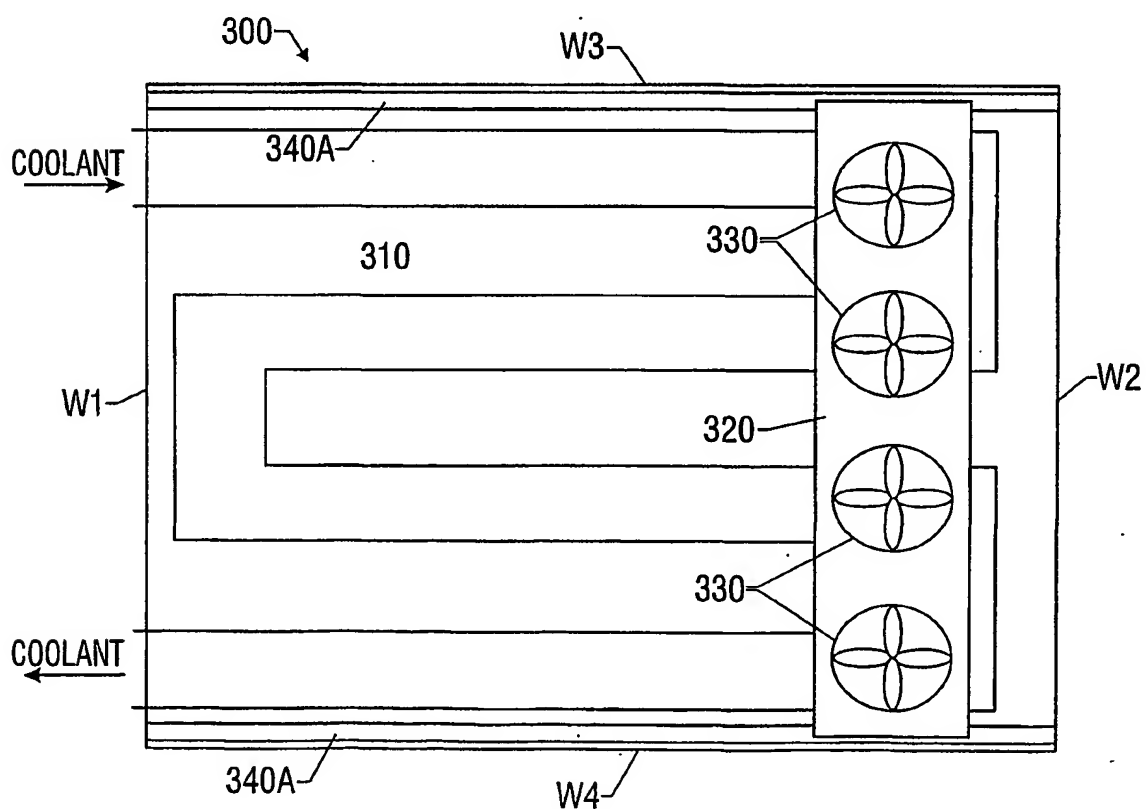


FIG. 4

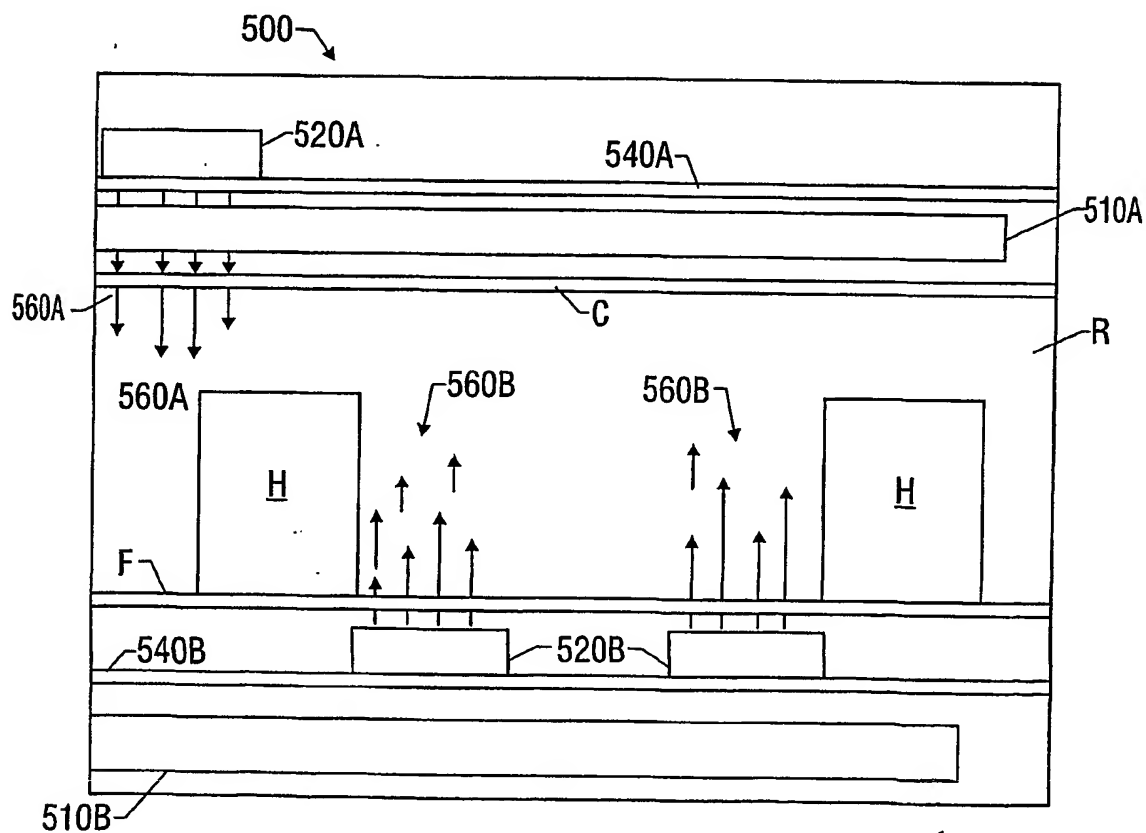
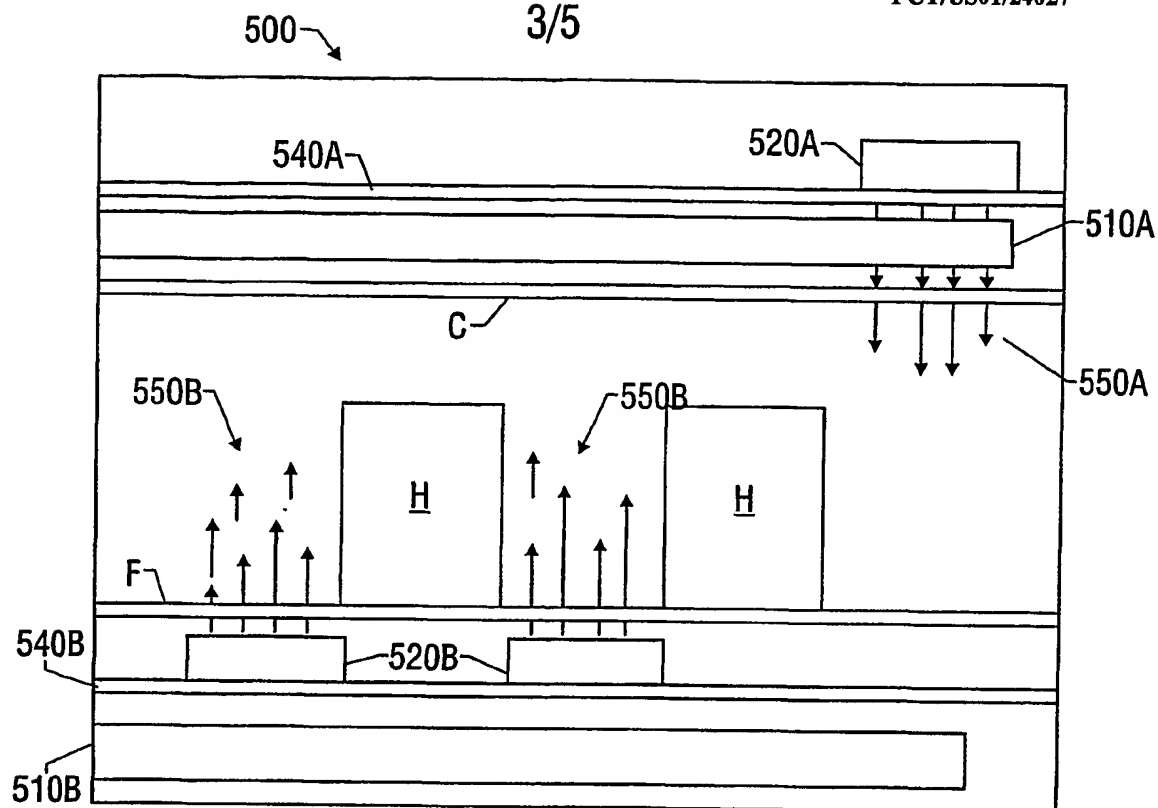


FIG. 6

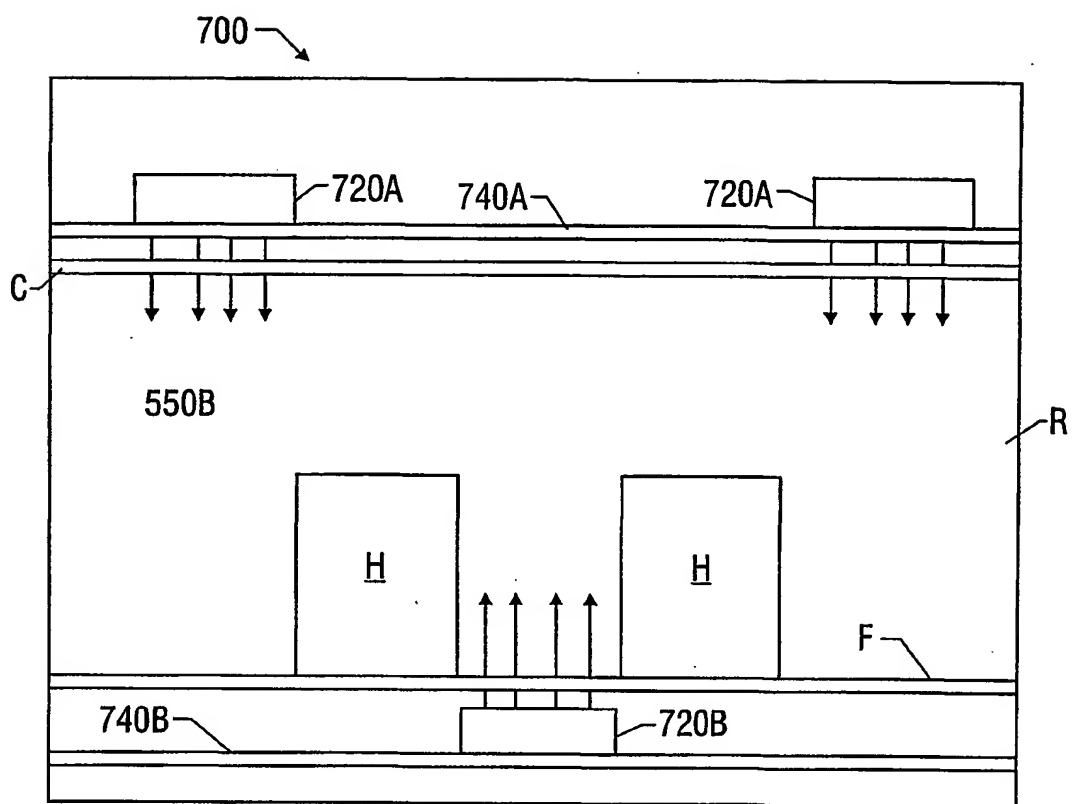


FIG. 7

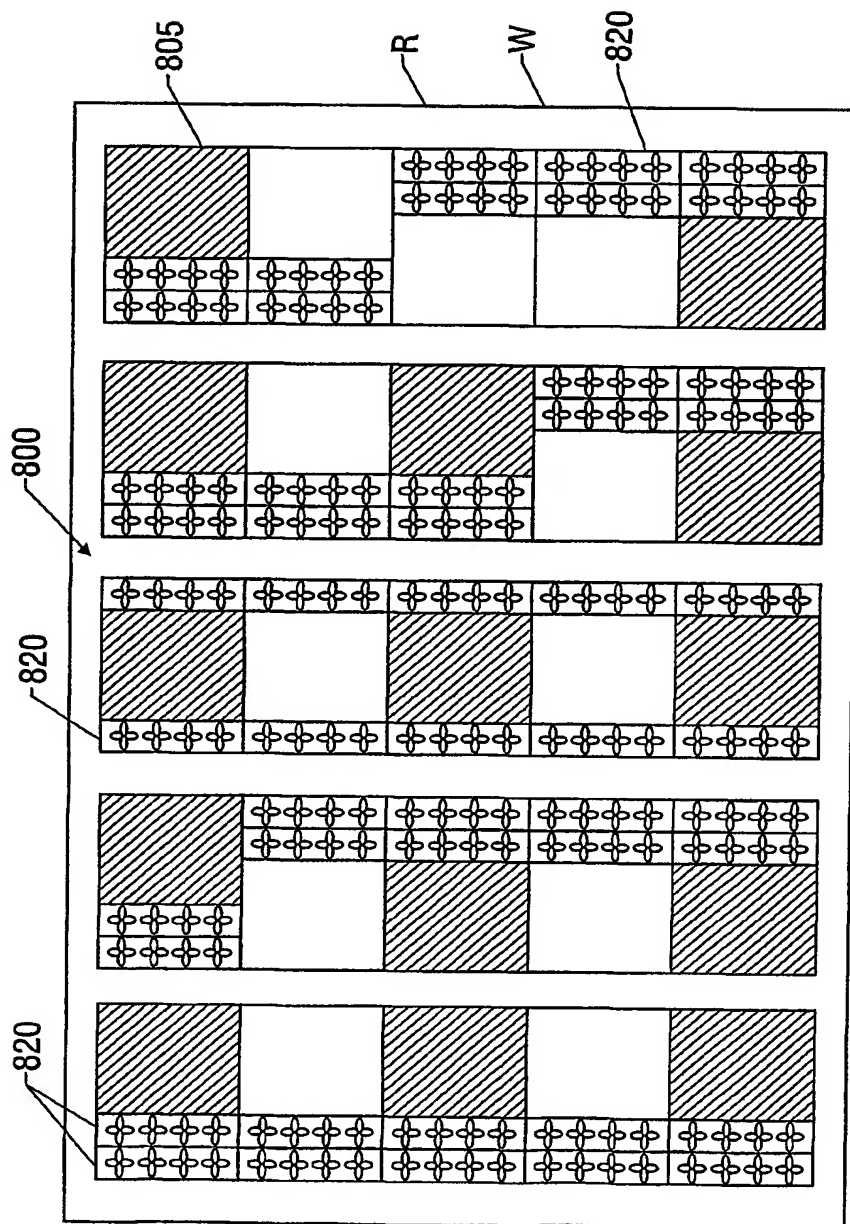


FIG. 8

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
14 February 2002 (14.02.2002)

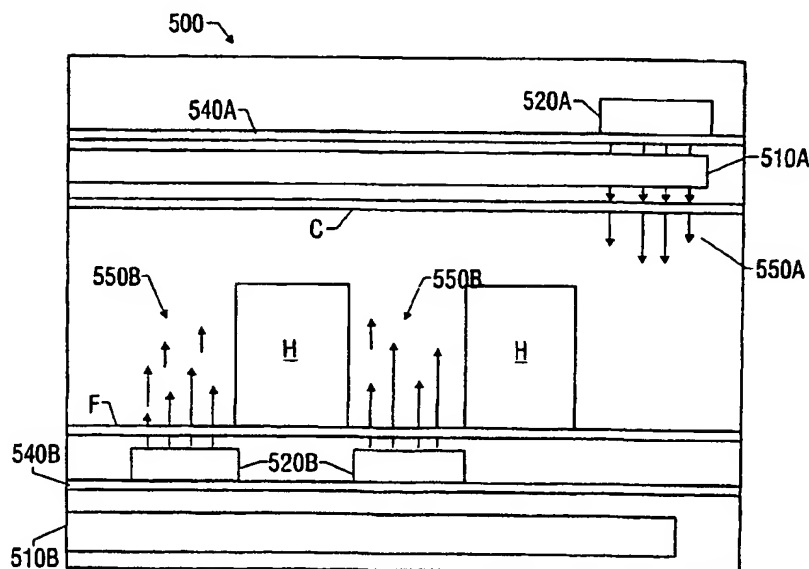
PCT

(10) International Publication Number  
**WO 02/12797 A3**

- (51) International Patent Classification<sup>7</sup>: **H05K 7/20, F24F 1/00**
- (21) International Application Number: **PCT/US01/24627**
- (22) International Filing Date: **6 August 2001 (06.08.2001)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:  
**09/635,374 9 August 2000 (09.08.2000) US**
- (71) Applicant: **EMERSON ELECTRIC CO. [US/US]; 8000 W. Florissant, St. Louis, MO 63136 (US).**
- (72) Inventors: **LENNART, Stahl; 1717 Poinciana Lane, Plano, TX 75075 (US). BELADY, Christian; 2202 Amherst Circle, McKinney, TX 75070 (US).**
- (74) Agent: **ALLEN, Billy, C., III; Howrey Simon Arnold & White, LLP, 750 Bering Drive, Houston, TX 77057-2198 (US).**
- (81) Designated States (*national*): **AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.**
- (84) Designated States (*regional*): **ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).**
- Published:  
— *with international search report*  
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

[Continued on next page]

(54) Title: **CONFIGURABLE SYSTEM AND METHOD FOR COOLING A ROOM**



(57) Abstract: A method and system are disclosed for cooling a room having one or more heat generating objects. A number of heat exchangers are disposed adjacent a floor or ceiling and extends substantially entirely or partially between the walls of the room. A fan unit is disposed adjacent the heat exchanger and draws or blows cooled air from the heat exchanger and directs the drawn air into the room. The fan unit is capable of being repositioned along a different portion of the heat exchanger so as to redefine the flow of cooled air into the room. The cooling system components are modularized enabling configuration of a number of components to cool a room.

WO 02/12797 A3

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*



## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 01/24627

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H05K7/20 F24F1/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H05K F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 218 838 A (ICHIKAWA YASUNORI ET AL) 15 June 1993 (1993-06-15) column 3, line 44 - line 57; figure 1  column 5, line 9 - line 18 ---	1,2,22  3-21, 23-30
X A	US 5 029 451 A (IMAIIDA TSUYOSHI ET AL) 9 July 1991 (1991-07-09) column 7, line 18 - line 43; figure 1 column 9, line 22 - line 36; figure 13 column 10, line 56 - line 35 ---	1  2-30
A	US 5 669 229 A (OHBA YASHI KAZUMI ET AL) 23 September 1997 (1997-09-23) column 4, line 5 - line 9; figure 1 ---	1-30
	--- -/--	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

\*A\* document defining the general state of the art which is not considered to be of particular relevance

\*E\* earlier document but published on or after the international filing date

\*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

\*O\* document referring to an oral disclosure, use, exhibition or other means

\*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*&amp;\* document member of the same patent family

Date of the actual completion of the international search

19 February 2002

Date of mailing of the international search report

26/02/2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

Rubenowitz, A

# INTERNATIONAL SEARCH REPORT

In International Application No

PCT/US 01/24627

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 786 300 A (UEMATSU MASAO ET AL) 22 November 1988 (1988-11-22) column 2, line 39 - line 68; figure 1 ---	1-30
A	EP 0 458 770 A (ERICSSON TELEFON AB L M) 27 November 1991 (1991-11-27) column 2, line 29 - line 52; figure -----	1-30

# INTERNATIONAL SEARCH REPORT

Information on patent family members

In International Application No

PCT/US 01/24627

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
US 5218838	A	15-06-1993	JP	3117241 B2	11-12-2000
			JP	5005537 A	14-01-1993
			GB	2255163 A ,B	28-10-1992
			KR	9603469 B1	14-03-1996
US 5029451	A	09-07-1991	JP	2078832 A	19-03-1990
			JP	2078850 A	19-03-1990
			JP	2103957 C	06-11-1996
			JP	8003384 B	17-01-1996
			JP	2078851 A	19-03-1990
			JP	2103958 C	06-11-1996
			JP	8003383 B	17-01-1996
			FR	2636412 A1	16-03-1990
			US	5097674 A	24-03-1992
US 5669229	A	23-09-1997	IT	1231666 B	18-12-1991
			JP	8327137 A	13-12-1996
			JP	8327140 A	13-12-1996
			JP	8327084 A	10-12-1996
US 4786300	A	22-11-1988	CN	1137626 A	11-12-1996
			JP	1727665 C	19-01-1993
			JP	4013612 B	10-03-1992
			JP	60023736 A	06-02-1985
			AU	548454 B2	12-12-1985
			AU	3059284 A	24-01-1985
EP 0458770	A	27-11-1991	GB	2143942 A ,B	20-02-1985
			KR	8902661 B1	22-07-1989
			SE	466932 B	27-04-1992
			CA	2041854 A1	22-11-1991
			DE	69101582 D1	11-05-1994
			DE	69101582 T2	21-07-1994
			EP	0458770 A1	27-11-1991
			ES	2051108 T3	01-06-1994
			JP	3025048 B2	27-03-2000
			JP	4227429 A	17-08-1992
			NO	177660 B	17-07-1995
			SE	9001829 A	22-11-1991

**THIS PAGE BLANK (USPTO)**